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(54) Receiver and method with enhanced performance for CDMA transmission

(57) Receiver for enhanced performance for CDMA radio transmission comprising rake receiver with a path searcher (3), a channel estimator (4) and a combiner (5) for selecting optimal paths where the path searcher selects a set of path delays (7) with an instantaneous profile analyzer (8), an averaging filter (9) and a path selector (10) where at least two instantaneous profile analyzers (8) are connected to the averaging filter (9).

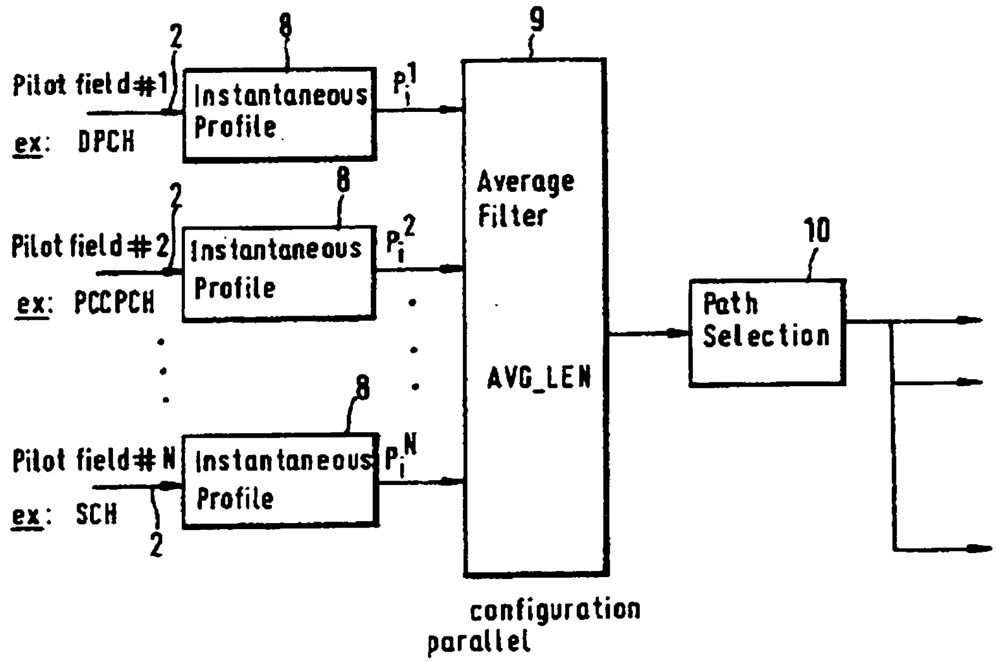


Fig.6

Description

[0001] The invention relates to a receiver and a method for enhanced performance for CDMA transmission as described in the subject of the independent claims.

[0002] In terrestrial communication the transmitted signal is reflected and refracted by a variety of smooth or rough terrains, so that it is replicated at the receiver with several time delays. Each individual path also arrives at is own amplitude and carrier phase. Propagation characteristics are qualitatively the same for all structures of signals though they will vary quantitatively with carrier frequency and terrain characteristics. The structures of the individual propagation paths can be identified and possibly exploited only on the extent that they can be distinguished from one other. In particular spread spectrum signals employ pseudo random sequences with chip time Tc inversely proportional to the spreading bandwidth. In this case the individual paths can be distinguished if they mutually separated by delays greater than Tc for then the various delayed versions of the signal will be mutually uncorrelated.

[0003] The situation is shown in Fig. 1. The path amplitudes α will depend on the relative propagation distances and the reflective or refractive properties of the area. However in many cases particularly in confined areas each of the distinguishable multipath components will actually be itself the linear combination of several indistinguishable paths of varying amplitudes. To exploit energy in the multiple components of multipath propagation they must be identifies and acquired. It is particularly important to determine the relative delays and subsequently when possible their amplitudes and phases. This can be performed even with fully modulated signals, but the estimate is much precise and resulting performance is much improved if the path identification and parameter estimation is performed on an unmodulated signal. Unmodulated segments can be inserted every so often in the modulated signal particularly with time division multiplexing. However in spread spectrum systems it is much more effective and easier to separate the unmodulated pilot signals from the data modulated signal by assigning it an individual pseudo random sequence.

[0004] A pilot sequence for determining multipath component characteristics is well justified for one-to-many transmission channels such as the forward down link from a base station to multiple users.
The optimum demodulator structure for a L multipath propagation channel is known as Rake receiver. Each mulipath component demodulator is called a "finger" of the rake. The pilot sequence tracking of a particular demodulator is started by time delay estimation of a given path as determined by the pilots sequences searcher. The demodulator forms the weighted phase-adjusted and delay-adjusted sum of L components. In prior art the profile of the powers of each of the L paths is taken by checking the pilot sequence of one pilot channel on a slot by slot basis. This power profile is computed by noncoherent averaging of instantaneous channel profiles performed on this slot by slot basis. So the demodulator has to wait for the next pilot sequence in the next time slot to get more information to optimize the power profile.
For downlink mode the performance of this solution depends extremely on the signal to noise ratio of the pilot sequence. This means that the result of the demodulation in the receiver depends on the pilot sequence length itself and the distortions in the dedicated channel.
Moreover for high bitrate the correlation length is shorter because of the lower spreading factor of the signal. Thus for different bit rates performances of the path selection algorithm can be different.

[0005] The invention as described below increases performance of a demodulator in a CDMA receiver due to a method using more than one pilot sequence to extract good information about path delays and so to get an optimized channel profile.

[0006] The improvements are done by:
A receiver with enhanced performance for CDMA transmission comprising rake receiver with a path searcher (3), a channel estimator (4) and a combiner (5) for selecting optimal paths where the path searcher selects a set of path delays (7) with an instantaneous profile analyzer (8), an averaging filter (9) and a path selector (10), characterized in that at least two instantaneous profile analyzers (8) are connected to the averaging filter (9)

[0007] Or:
A receiver with enhanced performance for CDMA transmission comprising rake receiver with a path searcher (3), a channel estimator (4) and a combiner (5) for selecting optimal paths where the path searcher selects a set of path delays (7) with an instantaneous profile analyzer (8), an averaging filter (9) and a path selector (10), characterized in that at least two probes of pilot sequences are selected by a selection element (12) and are connected to one instantaneous profile analyzer (8) over a P-S converter (11).

[0008] A preferred embodiment of the invention is shown in the figures and describes below.

Fig. 1 Multipath transmission
Fig. 2 Channel structure
Fig.3 Pilot sequences
Fig. 4 Receiver
Fig. 5 Prior art path searcher
Fig. 6 Inventional parallel receiver
Fig. 7 Inventional serial receiver

[0009] In prior art the dedicated physical channel (DPCH) and its pilot sequence is used to extract a power profile of the channels. In Fig. 2 two example of the DPCH 20 are shown with different spreading factors SF due to different bit rates. A pilot sequence 21 is followed by a data field 22. In the upper example the correlation

length is higher than in the example with a higher bit rate. So the performance of a receiver checking only the pilot sequence of the DPCH depends on the data rate.

[0010] Fig. 3 shows different channels that can be used in our invention. In the UTRA/FDD standard proposal several common channels 23 are transmitted in parallel on the downlink. For example primary and secondary common control physical channels (PCCPCH and SCCPCH) or SCH (Synchronization Channel) are broadcasted. These channels have a sufficient power to be detected anywhere in the cell and are transmitted with a constant bit rate except of the SCCPCH. The spreading factor is fixed with the bit rate. So to get a more reliable path selection in complement to the prior art, pilot sequences used for common channels can be used to have new additional power profiles of the channel. These new profiles are more reliable because downlink common channels are transmitters a relatively high power to be well detected by all users in the cell. Secondly most of these channels have a constant and low bit rate, so that pilot sequences are of a long duration. In terms of correlation properties long pilot sequences give more accurate results. This is a benefit in comparison with a power profile extracted from variable bit rate channels. A way to enhance performance is simply to use instantaneous profiles obtained by common channels in addition to those obtained from dedicated channel in process of noncoherent averaging of channel profiles. In Fig. 3 there is a solution depicted with two common channels 23 in combination with the dedicated channel 20. These three profiles are obtained to get a reliable profile and to reduce averaging period by combining the results.

[0011] Fig. 4 shows the functional block diagram of a rake receiver. The rake receiver 1 is a fundamental element of the mobile station demodulator. A typical Rake receiver comprises three basic algorithms: a *path searche* 3 a *channel estimator* 4 and a *combiner* 5. First, from a known pilot sequence 21, the *path searcher* 3 estimates the number and locations (time delays) 7 of the paths in a frequency selective channel. These delay estimates 7 are then used by the *channel estimator*4 to get the complex coefficients Ci of the propagation channel. Finally, the *combiner* coherently combines the channel coefficient estimates obtained for each path to enhance the useful data signal information before detection.

[0012] The principle of the Rake receiver is to combine the maximum number of different paths, by introducing delays in the receiver. These paths and delays (τ_i is the delay of the i^{th} path) are respectively detected and estimated by the functional block called path *searcher* 3. The second block of the Rake receiver is the *channel estimator* 4, which performs the estimation of the channel impulse response over all the detected paths by the *path searcher* 3. These estimations are also used to combine coherently each received path. This combination of the paths is performed by the *combiner* 5.

[0013] The path-searcher algorithm is an important functional part in a Rake receiver. The aim of this algorithm is to estimate the number and the location of the paths in a multipath channel. These estimations are also used by the *channel estimator* 4 and the *combiner*. Those are connected to the path searcher 3.

To detect paths, the *path searcher* 3 uses the pilot sequence 21 of the Dedicated Physical Channel 20. This pilot sequence is split on I&Q branches, spread with a Hadamard code and scrambled with a Gold code, according to the ETSI specification.

[0014] The path searcher needs a power *profile* prior to the path selection operation. The structure of a path searcher 3 in details is shown in figure 5. The path searcher comprises an instantaneous profile analyzer 8 connected to an averaging filter 9 and a path selector 10. The instantaneous profile analyzer 8 extract the energy distribution of the measured signal of the slot i of the pilot sequence 21. The result is an instantaneous power profile shown in fig. 5 over a definite window size. To get a more reliable profile it is computed by noncoherent averaging the instantaneous channel profiles performed on a slot by slot-basis. The noncoherent averaging is performed over *AVG_LENGTH* slots by an averaging filter 9. The instantaneous profiles Pi, p1+1... are used. The last step is the path selector that selected the pathes with power densities above a predefined threshold. The result is a set of delays.

[0015] To improve this path searcher performance the receiver is structured as shown in figure 6. Fig 6 is a parallel configuration of a receiver. There is a plurality of input signals 2 for example the DPCH, the PCCPCH or the SCH. The pilot sequences of these channels are connected to a selection device 12 taking a probe of each pilot sequence for further analysis. These single probes connected to a parallel-serial converter 11. The result is a data stream including channel information of more than one single pilot sequence. This data stream is analyzed in the way describes above. The P/S converter 11 is connected to an instantaneous profile analyzer 8, an averaging filter 9 and a path selector 10.

[0016] A second realization of the inventional idea is explained in figure 7. The incoming pilot sequences are inputted in parallel instantaneous profile analyzers 8. The analyzers 8 extract the instantaneous profiles P^N_i for each pilot sequence received. Than the single power profiles are averaged in one averaging filter 9 and the result selected by a path selector 10.

Claims

1. Receiver for enhanced performance for CDMA radio transmission comprising a Rake receiver (1) with a path searcher (3), a channel estimator (4) and a combiner (5) for selecting optimal channels paths where the path searcher (3) selects a set of path

delays (7) with an instantaneous profile analyzer (8), an averaging filter (9) and a path selector (10), characterized in that at least two instantaneous profile analyzers (8) are connected to the averaging filter (9).

2. Receiver for enhanced performance for CDMA radio transmission comprising a Rake receiver with a path searcher (3), a channel estimator (4) and a combiner (5) for selecting optimal channel paths where the path searcher (3) selects a set of path delays (7) with an instantaneous profile analyzer (8), an averaging filter (9) and a path selector (10), characterized in that at least two probes of pilot sequences (21) are selected by a selection element (12) and are connected to one instantaneous profile analyzer (8) over a S/P-converter (11).

3. Receiver as in claim 1 or claim 2 using parallel extraction of data from parallel received channels enclosing pilot sequences.

4. Receiver as in claim 1 or 2 using channels with fixed bit rates and/or channels with varying bit rates.

5. Method for extracting power profiles from a plurality of radio frequency channels in a multi path transmission to search an optimal transmission path, characterized in that more than one pilot sequence is analyzed and the analyzed information is averaged to get the relevant path delays.

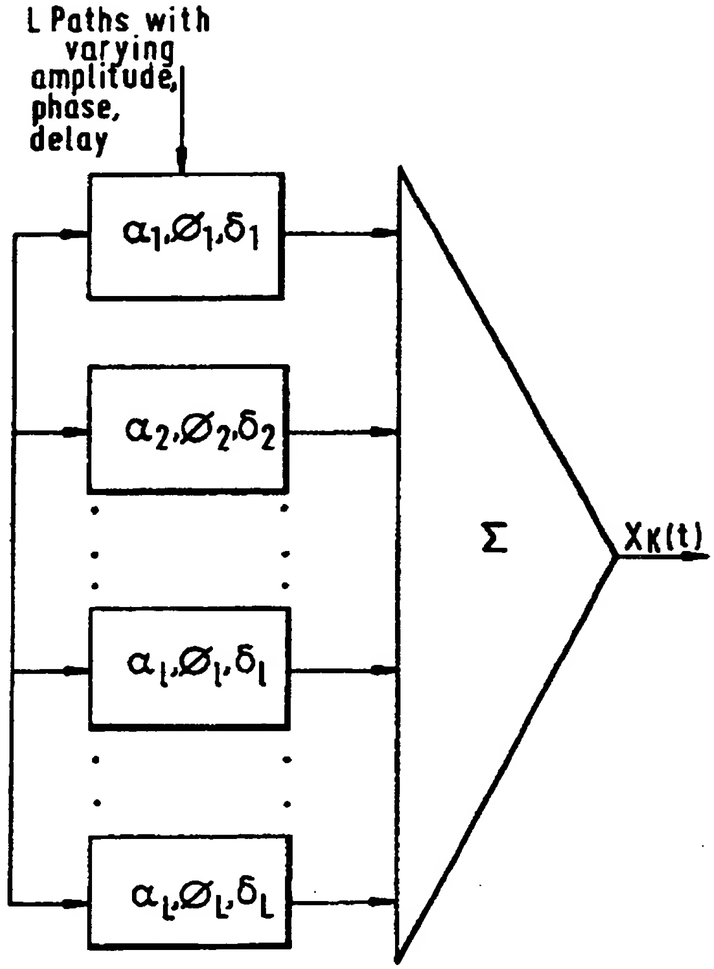

L Paths with varying amplitude, phase, delay
$\alpha_1, \varnothing_1, \delta_1$
$\alpha_2, \varnothing_2, \delta_2$
$\alpha_l, \varnothing_l, \delta_l$
$\alpha_L, \varnothing_L, \delta_L$
Σ
$x_K(t)$

Fig.1

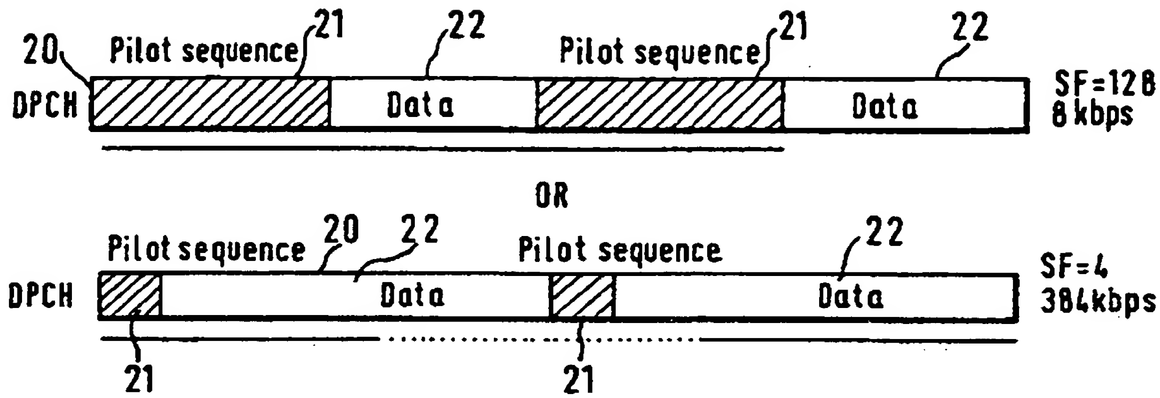

20
DPCH
Pilot sequence
21
22
Data
Pilot sequence
21
22
Data
SF=128
8 kbps
OR
Pilot sequence
20
22
Data
Pilot sequence
22
Data
DPCH
SF=4
384kbps
21
21

Fig.2

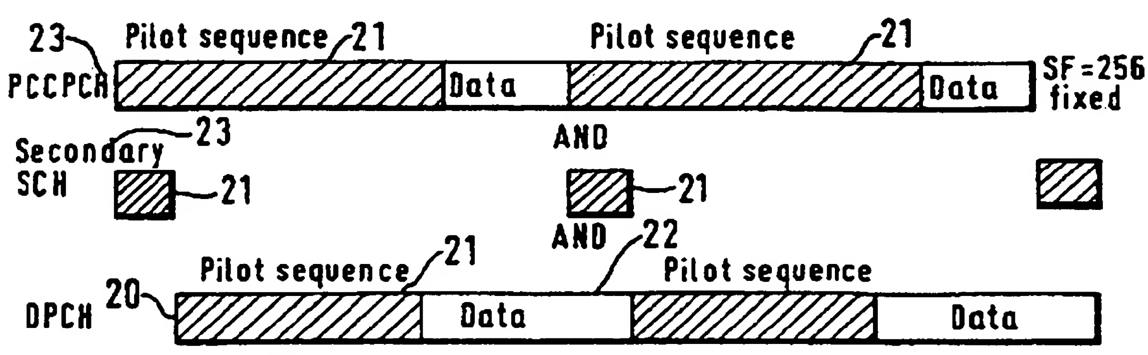

23
PCCPCH
Pilot sequence
21
Data
Pilot sequence
21
Data
SF=256
fixed
Secondary
SCH
23
21
AND
21
AND
22
Pilot sequence
21
20
DPCH
Data
Pilot sequence
Data

Fig.3

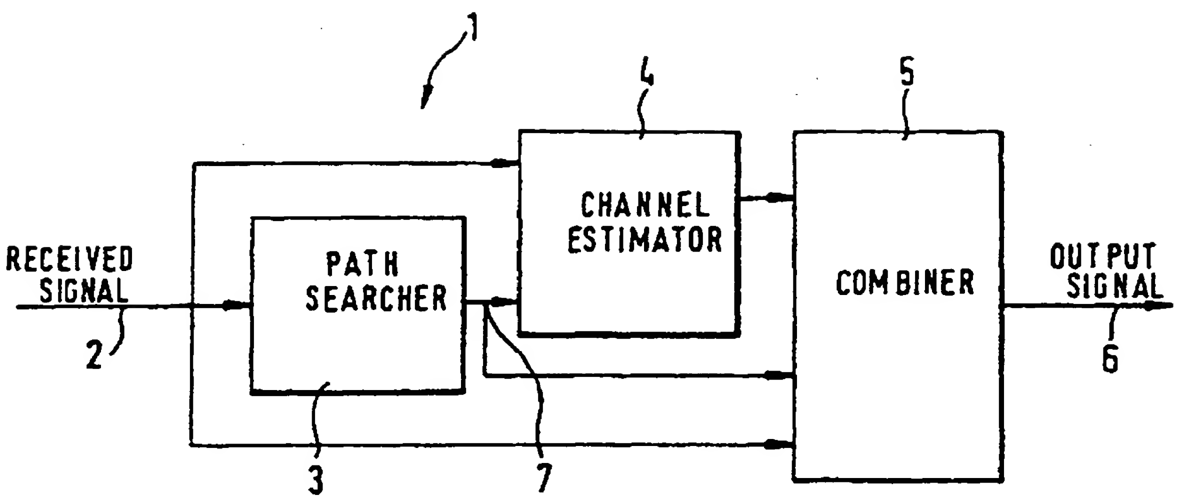
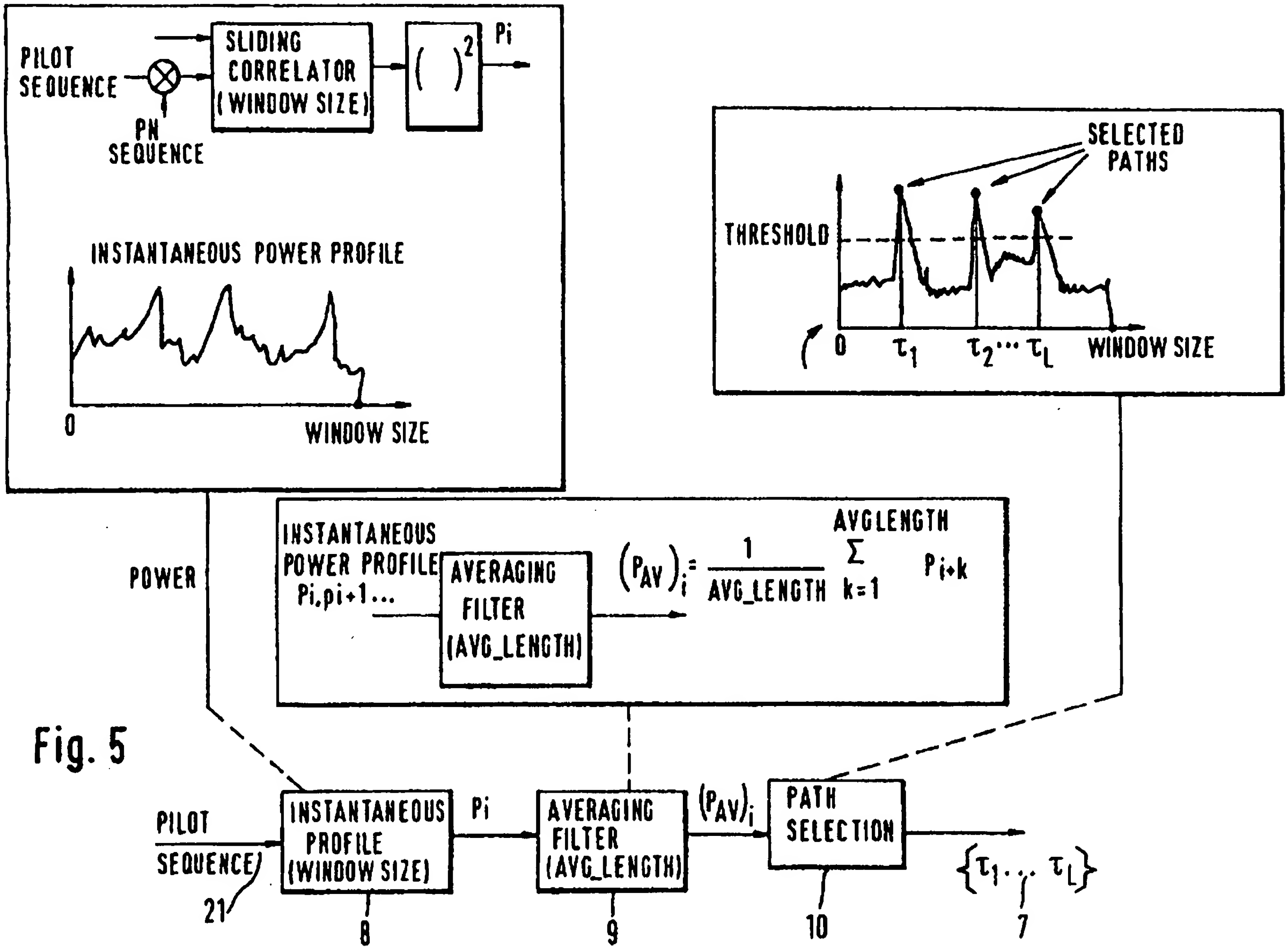

1
4
5
CHANNEL ESTIMATOR
RECEIVED SIGNAL
PATH SEARCHER
COMBINER
OUTPUT SIGNAL
2
6
3
7

Fig. 4



PILOT SEQUENCE
PN SEQUENCE
SLIDING CORRELATOR (WINDOW SIZE)
( )²
Pi
INSTANTANEOUS POWER PROFILE
0
WINDOW SIZE
SELECTED PATHS
THRESHOLD
0
τ1
τ2 ... τL
WINDOW SIZE
POWER
INSTANTANEOUS POWER PROFILE Pi,pi+1...
AVERAGING FILTER (AVG_LENGTH)
$(P_{AV})_i = \frac{1}{AVG\_LENGTH} \sum_{k=1}^{AVGLENGTH} P_{i+k}$
PILOT SEQUENCE
21
INSTANTANEOUS PROFILE (WINDOW SIZE)
8
Pi
AVERAGING FILTER (AVG_LENGTH)
9
$(P_{AV})_i$
PATH SELECTION
10
$\{\tau_1 \ldots \tau_L\}$
7

Fig. 5

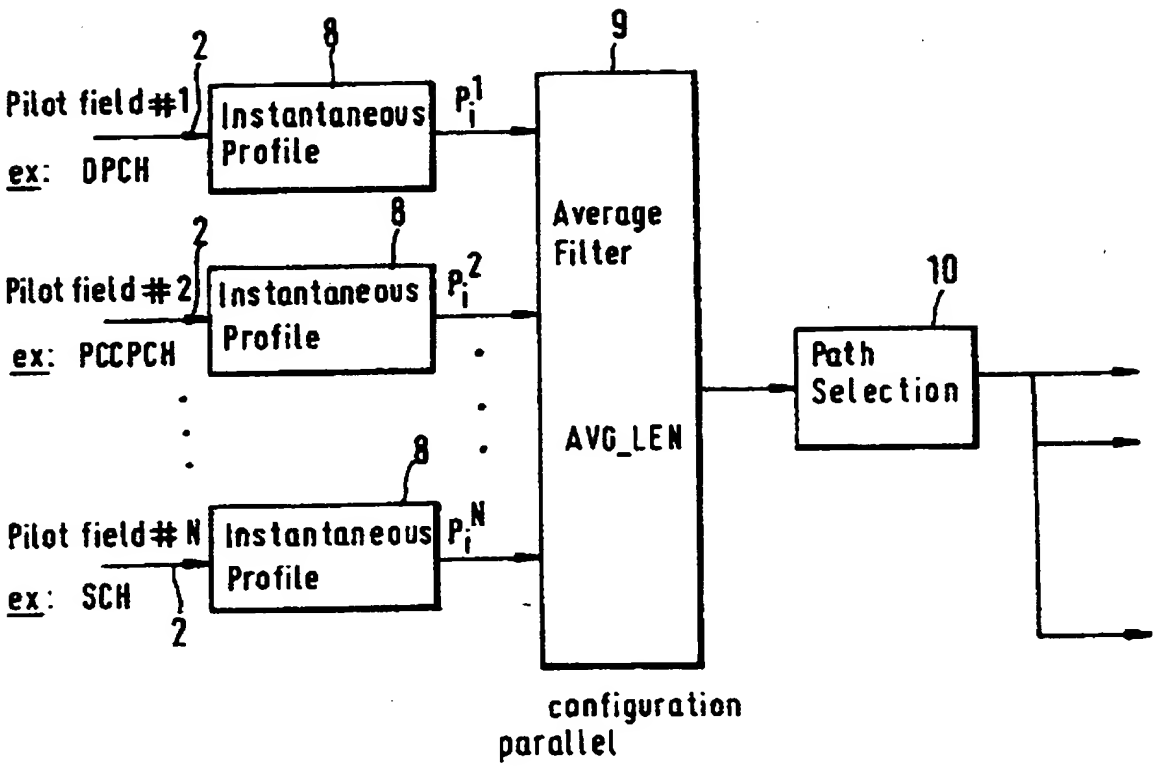

2
8
9
Pilot field #1
ex: DPCH
Instantaneous Profile
P_i^1
Average Filter
AVG_LEN
2
8
Pilot field #2
ex: PCCPCH
Instantaneous Profile
P_i^2
10
Path Selection
8
Pilot field # N
ex: SCH
Instantaneous Profile
P_i^N
2
configuration parallel

Fig.6

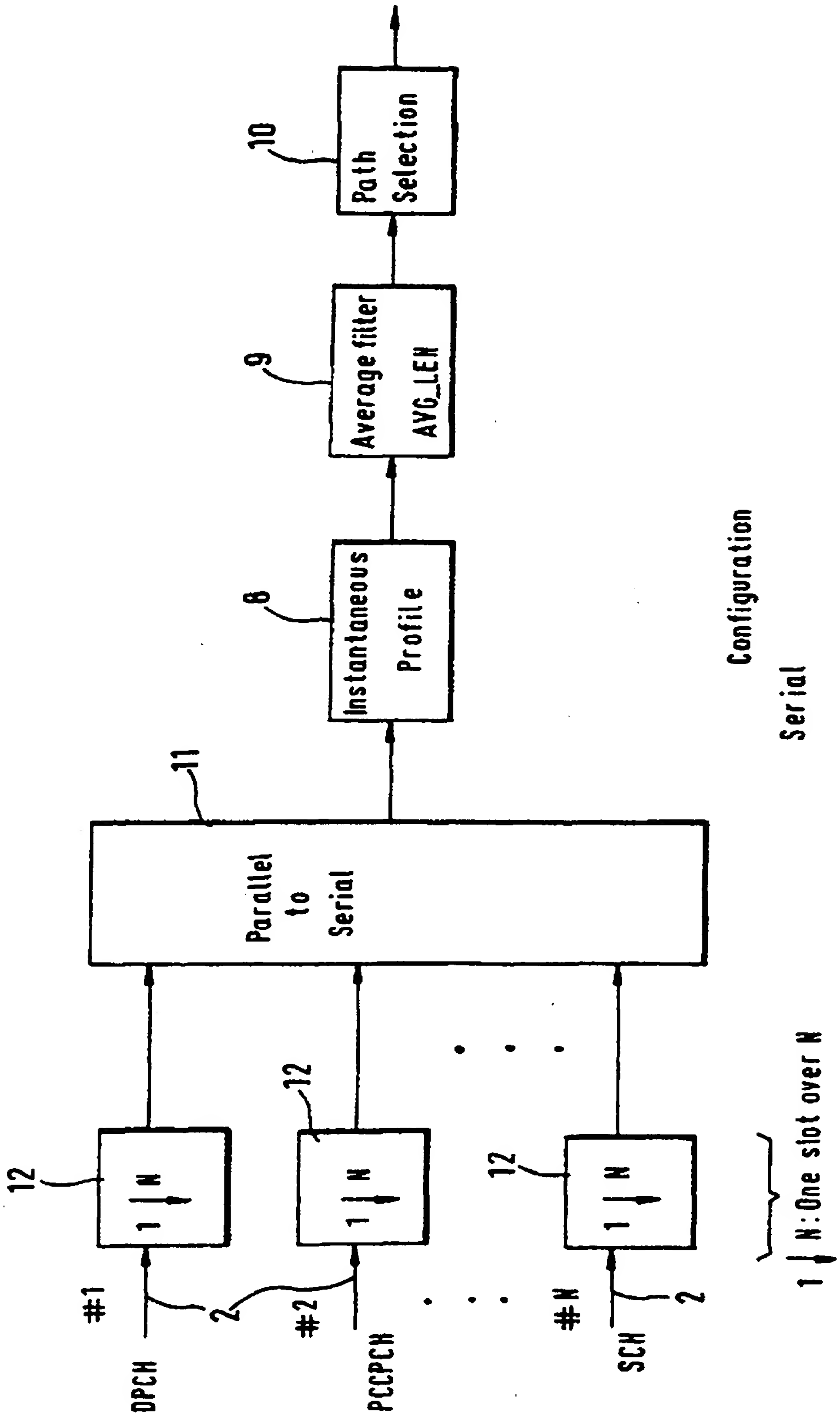

DPCH
#1
PCCPCH
#2
SCH
#N
2
12
1 ↓ N
Parallel
to
Serial
11
Instantaneous
Profile
8
Average filter
AVG_LEN
9
Path
Selection
10
1 ↓ N: One slot over N
Serial
Configuration

Fig.7

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EUROPEAN SEARCH REPORT

Application Number
EP 99 44 0158

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X A	EP 0 836 288 A (MATSUSHITA ELECTRIC IND CO LTD) 15 April 1998 (1998-04-15) * column 12, line 23 - line 40 * * column 12, line 53 - column 13, line 17 * * column 14, line 31 - line 33 * * column 14, line 44 - line 47 * * column 15, line 28 - line 43 * * figures 1-4 *	5 1,2	H04B1/707
A	EP 0 798 870 A (MATSUSHITA ELECTRIC IND CO LTD) 1 October 1997 (1997-10-01) * column 2, line 18 - line 40; figure 10 *	1-5	
A	EP 0 749 215 A (SHARP KK ;SHARP MICROELECT TECH INC (US)) 18 December 1996 (1996-12-18) * page 4, line 4 - line 14 * * page 5, line 35 - page 6, line 15; figure 4 * * claim 1 *	1-5	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	BAIER A ET AL: "DESIGN STUDY FOR A CDMA-BASED THIRD-GENERATION MOBILE RADIO SYSTEM" IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS,US,IEEE INC. NEW YORK, vol. 12, no. 4, page 733-743 XP000588850 ISSN: 0733-8716 * page 735, column 1, line 42 * * page 735, column 2, line 13 - line 28 * * page 735, column 2, line 38 - page 736, column 1, line 2 * * page 740, column 2, line 1 - line 13; figure 8 *	1-5	H04B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17 November 1999	Ó Donnabháin, E

CATEGORY OF CITED DOCUMENTS

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& : member of the same patent family, corresponding document

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17-11-1999

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